Image AF/1725

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MAIL STOP APPEAL BRIEF-PATENTS

0503-1089

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re application of

FRANCIS BRIAND et al.

Serial No. 09/870,014 Appeal No. ___________

Filed May 31, 2001 GROUP 1725

LASER/ARC HYBRID WELDING PROCESS
WITH APPROPRIATE GAS MIXTURE

APPEAL BRIEF

MAY IT PLEASE YOUR HONORS:

1. Real Party in Interest

The real party in interest in this appeal is the assignee, L'Air Liquide Societe Anonyme A Directoire et Conseil De Surveillance Pour L'Etude et L'Exploitation Des Procedes Georges Claude, of Paris, France.

2. Related Appeals and Interferences

None.

3. Status of Claims

Claims 1-2, 7-9, 15-16, and 18-25 stand rejected. Claims 3-6, 10-14, 17, and 26-28 have been cancelled. A listing of the claims is attached.

4. Status of Amendments

An Amendment after Final Rejection was filed on August 28, 2003, canceling claims 26-28. The Advisory Action of October 2, 2003 (Paper No. 13) indicated that this

amendment would be entered. Accordingly, the claims on appeal are claims 1-2, 7-9, 15-16, and 18-25.

5. Summary of Invention

The invention is an arc/laser hybrid welding process for welding steel workpieces.

Such hybrid welding uses a laser beam simultaneously with an electric arc (specification page 5, second and third full paragraphs; specification page 7, forth full paragraph).

In the invention, a part of the welding zone including the joint currently being welded is shielded with a ternary gas mixture. The ternary gas mixture consists of argon, helium, and one of oxygen and carbon dioxide. The argon and helium have a content of at least 70% by volume. The third gas (O_2 or CO_2) has a non-zero content up to 30% by volume (specification page 7, final paragraph).

The invention's use of this particular ternary gas mixture in laser-arc welding is novel, as to any metals including the recited steel.

6. Issues

A first issue on appeal is whether independent claim 1 was properly rejected under §103(a), over HAMASAKI 4,507,540 in view of STEEN 4,167,662 and YENNI et al.

2,753,427; CHERNE et al. 4,871,898; or GALANTINO et al. 4,749,841 (Group A references).

A second issue on appeal is whether claim 1 was properly rejected under §103(a), over HAMASAKI in view of STEEN and GALANTINO 4,902,866 (Group B references).

A third issue on appeal is whether the dependent claims were properly rejected. Claims 2, 7-9, 15, 22, 23, and 25 were rejected over the Group A references, claims 16, 18, 19, and 21 in further view of BEYER et al. 5,821,493., and claim 20 in further view of COOK 2,790,656. Claims 2, 7-9, 15, 22, and 24 were rejected over the Group B references, claims 16, 18, 19, and 21 in further view of BEYER et al., and claim 20 in further view of COOK.

7. Grouping of Claims

As to each of the first and second issues on appeal, claim 1 stands alone.

As to the third issue on appeal, the dependent claims stand together with independent claim 1.

8. Arguments

Arguments Concerning the First Issue

The first obviousness rejection of claim 1 is over HAMASAKI in view of STEEN and any of YENNI et al., CHERNE et al., and GALANTINO et al.

Claim 1 recites hybrid laser-arc welding of steel workpieces with a ternary gas mixture consisting of argon, helium and either oxygen or carbon dioxide.

The Examiner has offered HAMASAKI disclosing welding steel workpieces by hybrid laser-arc welding and binary gas mixtures.

Thus, although HAMASAKI does disclose hybrid laser-arc welding of steel pieces using various binary gas mixtures, HAMASAKI fails to teach the use of ternary gas mixtures. Specifically, HAMASAKI fails to disclose the recited ternary gas mixture and fails to disclose the specific amounts of the different gases of the gas mixtures as recited. See the first full paragraph on page 3 of the July 16, 2003 Official Action.

Bottom line, the disputed issue is whether any of the applied prior art documents render obvious the use of the recited ternary gas mixture consisting of argon, helium and either oxygen or carbon dioxide, in the concentrations recited, for ***hybrid laser-arc welding*** of steel pieces.

In considering the question of obviousness, one must consider the state of the art at the time of the invention and what would have been obvious to one of skill *at that time*. It is well established that, to establish a *prima facie* case of obviousness, the Examiner must first

consider the relevant teachings of the prior art. Next, the Examiner determines the differences between the pending claim and the prior art teachings. Lastly, the Examiner may propose modifications of the prior art necessary to arrive at the claimed subject matter, but the Examiner must show that there is proper motivation for combining the particular references and for making the proposed modifications to those references. Thus, there must be motivation to modify the references and a teaching or suggestion, in the prior art, of **all** the claim's recitations.

Applying this procedure to the facts of the present case, we see that the Examiner has found prior art (HAMASAKI) disclosing hybrid laser-arc welding of steel pieces using various binary gas mixtures.

The Examiner has not found any prior art disclosing the use of any ternary gas mixture in a hybrid laser-arc welding method.

The Examiner was therefore forced to look outside the welding method being recited; that is, to look outside of hybrid laser-arc welding methods.

As noted above, this obviousness rejection is based on HAMASAKI plus STEEN together with any one of YENNI et al., CHERNE et al., and GALANTINO et al.

In the second full paragraph on page 3 of the July 16, 2003 Official Action, STEEN is offered as disclosing "a hybrid [laser-arc] welding process in which TIG or MIG electrodes can be used" referring to column 4, lines 63-66.

Lines 63-66 actually discloses a welding using an electrode system that may be ***similar*** to that used in MIG or TIG. Thus, STEEN does not appear to teach TIG or MIG welding in a hybrid laser-arc welding process. In any event, STEEN is not offered for the missing ternary gas mixture.

YENNI et al., CHERNE et al., and GALANTINO et al. were each offered as teaching arc welding with a shielding gas mixture of argon, helium, and carbon dioxide.

None of these, however, disclose this gas mixture with hybrid laser-arc welding.

So, at this point we have the prior art disclosing hybrid laser-arc welding with binary gas and arc welding with the ternary gas mixture.

What the Examiner is missing is motivation for using the ternary gas mixture, known only for use in arc welding, in the hybrid laser-arc welding method.

The Examiner's position is essentially that it is obvious to try any technique for arc welding in hybrid welding methods, i.e., "obvious to try". The Examiner has

failed to consider whether one of skill would expect an arc welding teaching to transfer to hybrid welding.

This failure is important as it is known that the prior art laser welding and arc welding techniques do not have the same results and characteristics when applied to hybrid welding; that is, importation of either laser welding or arc welding techniques into hybrid welding is unpredictable.

The amendment of May 1, 2003 made of record The Welding Institute (TWI) public release dated 2002 (copy attached). At the bottom of the first page, TWI reports that synergistic effects of laser-TIG welding were **not** found when low power was used. On the second page of this article, in the paragraph preceding the Main Conclusions section, TWI reports that augmenting a carbon dioxide laser with an arc resulted in less penetration than in laser welding alone. Thus, while hybrid welding was known to offer promise, it was also known that hybrid welding results nonetheless cannot be predicted.

The Examiner, in making the obviousness rejection, fails to consider that one of skill would not assume that gas mixtures known for arc or laser welding could be transferred to hybrid welding applications. The Examiner should have paid attention to the knowledge level that was

present at the time of the invention so as to avoid impermissible hindsight obtained from the present application or subsequent developments in the art.

The prior art understood that laser and arc welding are two very different welding processes such that when arc welding and laser welding are combined, it is often uncertain how they will affect each other. This means that those skilled in the art understand that what may be "true" in arc welding cannot be assumed to be "true" in laser welding or in hybrid welding.

As a consequence, it would be erroneous to consider any gas mixture usable in arc welding is automatically usable in hybrid welding.

Appellants acknowledge that the cited secondary references teach ternary gas mixtures for arc welding. Note, however, that none of these references concern hybrid welding or suggest hybrid welding and so none of these references teach a benefit of using a ternary gas mixture to improve hybrid welding. Indeed, in each instance where hybrid welding is disclosed in the prior art, there is no disclosure of using a ternary gas, and in any instance where a ternary gas mixture is disclosed, there is no disclosure using such gas mixture in hybrid welding. Appellants believe that this clearly points to the prior art not

appreciating any benefit from using ternary gases in conjunction with hybrid welding.

It seems that the Examiner effectively used the present disclosure to render the claimed invention obvious. Such an approach is not permitted.

Relevant to this point, the Federal Circuit emphasized in July, 1998 that "[m]ost, if not all, inventions are combinations and mostly of old elements." *In re Rouffett*, 47 USPQ 2d 1453, 1457 citing to *Richdel, Inc. v. Sunspool Corp.*, 219 USPQ 8, 12 (Fed. Cir. 1983). The Federal Circuit continued by noting that "rejecting patents solely by finding prior art corollaries for the claimed elements would permit an examiner to use the claimed invention itself as a blue print for piecing together elements in the prior art to defeat the patentability of the claimed invention."

Thus, the Federal Circuit requires that in order to prevent the use of such hindsight, the Official Action must "show reasons that the skilled artisan, confronted with the same problems as the inventor and with no knowledge of the claimed invention, would select the elements from the cited prior art references for combination in the manner claimed." (*In re Rouffett* at 1458).

Appellants believe that it is clear that although the prior art was aware of the use of ternary gas mixtures for arc welding, the prior art fails in any instance to suggest such use in hybrid welding. When avoiding the use of hindsight, it is clear the claim 1 is non-obvious. Therefore the obviousness rejection can not be maintained.

Arguments Concerning the Second Issue

A second obviousness rejection is over HAMASAKI in view of STEEN and GALANTINO.

As with the first obviousness rejection, the combination of HAMASAKI and STEEN is acknowledged not to teach the recited ternary gas mixture.

GALANTINO teaches a ternary gas mixture of argon, helium, and oxygen. GALANTINO teaches this ternary gas mixture for arc welding.

Thus, this second obviousness rejection is the same as the first obviousness rejection except for showing the alternative third gas (oxygen instead of carbon dioxide). In view of this, appellants believe this rejection fails for the same reasons argued as to the first obviousness rejection.

Accordingly, as to this second obviousness rejection, the Examiner also fails to establish a *prima facie*

case of obviousness. Therefore, the rejection can not be maintained.

Arguments Concerning the Third Issue

The dependent claims are believed allowable at least for depending from allowable claim 1.

9. Conclusion

In view of foregoing, it follows that the obviousness rejections are all improper and should be reversed.

Reversal of these rejections is accordingly respectfully solicited.

Respectfully submitted,

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December 19, 2003

10. Appendix

The claims on appeal:

1. (previously presented) A process for welding one or more metal workpieces to be joined together by producing at least one welded joint between edges to be welded of said metal workpiece or workpieces, said workpiece or workpieces being made of steel, by using at least one laser beam and at least one electric arc, in which process, during welding of the joint, shielding at least one part of a welding zone comprising at least one part of said welded joint during welding with at least one shielding atmosphere formed by a ternary gas mixture consisting of:

argon;

helium, the argon and the helium with a content greater than or equal to 70% by volume; and

a third gas consisting of O_2 or CO_2 with a content of non zero to 30% by volume.

2. (previously presented) The welding process as claimed in claim 1, wherein the content of O_2 or CO_2 is non zero and less than or equal to 20% by volume.

3-6. (cancelled)

7. (previously presented) The welding process as claimed in claim 1, wherein the shielding atmosphere is

formed by a gas mixture consisting of at least 70% by volume of helium and argon and of 0.1 to 30% by volume of O_2 or CO_2.

8. (previously presented) The welding process as claimed in claim 1, wherein the workpiece or workpieces to be welded are made of coated or uncoated steels.

9. (previously presented) The welding process as claimed in claim 1, wherein the workpiece or workpieces to be welded are made of stainless steel or carbon steel.

10-14. (cancelled)

15. (previously presented) The welding process as claimed in claim 1, wherein the laser beam is emitted by an Nd:YAG or CO_2 laser and/or wherein the electric arc is a plasma arc.

16. (previously presented) The welding process as claimed in claim 1, wherein the electric arc is delivered by a plasma-arc torch.

17. (cancelled)

18. (previously presented) The welding process as claimed in claim 1, wherein said metal workpiece comprises at least one tailored blank intended to constitute at least one part of a vehicle body element.

19. (previously presented) The welding process as claimed in claim 1, wherein said metal workpieces have different thicknesses.

20. (previously presented) The welding process as claimed in claim 1, wherein said metal workpieces have the same or different thicknesses and have different metallurgical compositions or metallurgical grades.

21. (previously presented) The welding process as claimed in claim 1, wherein the edges comprise two longitudinal edges of a pre-tube.

22. (previously presented) The welding process as claimed in claim 1, wherein the electric arc is generated by a consumable or a non-consumable electrode.

23. (previously presented) The welding process as claimed in claim 1, wherein the third gas consists of CO_2 with a content of non zero and less than 15% by volume.

24. (previously presented) The welding process as claimed in claim 1, wherein the third gas consists of O_2 with a content of non zero and less than 5% by volume.

25. (previously presented) The welding process as claimed in claim 1, wherein the third gas consists of CO_2 with a content of non zero and less than 2% by volume.

26-28. (cancelled)

Background

The tungsten inert gas (TIG) arc welding process was the first to be combined with a laser beam to produce an arc-augmented laser, or hybrid laser-arc weld in the mid 1970s (1). Since then, laser welding has successfully been augmented with other arc processes such as metal inert/active gas (MIG/MAG) welding and plasma welding. The advantages of using hybrid laser-arc welding for increased productivity include faster welding speeds, improved penetration, enhanced gap bridging capability and reduced porosity compared with conventional laser welding. Hybrid welding has been studied for application in industries such as automotive (5), oil and gas (7, 8), shipbuilding (9) and nuclear (10).

This report reviews the published literature on the capabilities of hybrid laser-arc welding. Also, a programme of experimental work was undertaken to establish suitable procedures for hybrid CO_2 laser-MAG arc welding carbon steel, compared to welding with the individual processes.

Objectives

- To review published literature on hybrid laser-arc welding to establish procedures for initial trials for hybrid CO_2 laser-MAG welding carbon steel.

- To determine process guidelines for using hybrid CO_2 laser-MAG welding technology for welding steel.

Summary of Literature Review

Experimental research into laser-arc hybrid welding has demonstrated that it combines many of the best features of the individual processes. MIG/MAG welding provides a relatively wide bead and good tolerance to variations in fit-up and the possibility of metallurgical control. Laser welding provides deep penetration welds at fast welding speeds. The synergistic action of combining the individual processes is more than simply additive; considerable reductions in costs and improvements in productivity are achievable relative to the separate processes.

The use of filler wire and a more diffuse heat source with the arc process means that hybrid laser-arc welding can tolerate misalignments and large root gaps in thick section welding better than laser welding alone. Therefore the accuracy and tolerances required for workpiece preparation are relaxed.

For the very low additional costs of the arc compared with the laser, hybrid welding reportedly offers faster welding speeds and lower cycle times thus, the production cost per unit can be reduced compared to laser welding. A reduction in investment costs for laser technology will further facilitate the acceptance of the process for future industrial applications. In most cases the enhancement of weld penetration of hybrid welding compared with laser alone welding has been reported. However, this is not always the case. Scott (38) concluded that there were no synergistic effects of the laser increasing the penetration of TIG welds in several aluminium alloys.

However, these results were explained by the low power laser used, which did not produce a keyhole.

Experimental Approach

Following an extensive literature review, a programme of work was undertaken to establish the feasibility of using hybrid CO_2 laser-MAG welding of carbon steel in order to obtain greater weld penetration at faster speeds than for laser welding. Processing parameters investigated in this assessment of hybrid laser-arc welding include gas composition, welding speed, welding direction (laser trailing or leading the arc) and MAG metal transfer mode.

Results and Discussion

The literature review showed that it is possible to improve productivity using the hybrid laser-arc welding process, compared with either laser or MAG arc welding. Costs are considerably reduced using a hybrid laser-arc process compared with a laser only process of equivalent power.

Bead-on-plate welding trials used a MIG/MAG welding torch inclined at 60° to the workpiece, and pulsed and dip metal transfer conditions of equivalent power to the 4kW CO_2 laser. A 3kW MAG arc using a pulsed metal transfer condition, 4kW CO_2 laser, He-Ar-CO_2 shielding gas and the arc trailing the laser was found to give 25% greater penetration than the laser welds. For a given penetration, these conditions also gave a 50% increase in welding speed compared with a laser weld. The thermal efficiency factor of the hybrid process is increased to 0.9, compared with 0.78 or 0.8 for CO_2 laser or MAG welding respectively, for welding speeds up to 3.0 m/min.

Trials were also undertaken to investigate welding with a 4.2kW CO_2 laser augmented with a 12.5kW MAG arc. Spray metal transfer conditions and a shallow torch inclination angle of 40° was used, and the shielding gas was He-Ar-CO_2. The penetration of these hybrid welds was less than the penetration in laser welds. This was due to the high arc currents used in the spray metal transfer condition causing an excess of weld metal in the keyhole, effectively blocking the penetration of the laser.

Main Conclusions

- He-Ar-CO_2 shielding gas was found to give the best combination of process stability and penetration for hybrid 4kW CO_2 laser-3kW pulsed MAG welding.

- The MIG/MAG welding torch trailing the CO_2 laser for a hybrid 4kW CO_2 laser-3kW pulsed MAG welding process was found to increase penetration of the hybrid weld.

- For a constant depth of penetration (in this case 4.2mm penetration) the hybrid CO_2 laser-MAG welding process was capable of increasing welding speed by around 50% compared to laser alone welding.

- Hybrid CO_2 laser-MAG welding provided an increase in weld penetration of 20-35% compared with laser alone welding at constant welding speed of 3.0 m/min.

- The average process efficiency factor was found to be 0.9 for hybrid 3.8kW CO_2 laser-2.6kW MAG welds, compared with approximately 0.8 for the individual laser and MAG processes. The total weld area of hybrid 3.8kW CO_2 laser-2.6kW MAG welds was greater than the sum of the weld areas for the individual processes below 3.0 m/min.

Recommendations

It is recommended that to improve the penetration and welding speed of bead-on-plate welding carbon steel, the following welding conditions using a hybrid CO_2 laser-MAG welding process are:

- Pulsed MAG metal transfer conditions;
- 55%He-43%Ar-2%CO_2 shielding gas;
- 1.5 m/min welding speed;
- MAG arc trailing the laser;
- 0mm separation between the MAG arc and the CO_2 laser in the molten pool.

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LASER/ARC HYBRID WELDING PROCESS
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APPEAL BRIEF

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1. Real Party in Interest

The real party in interest in this appeal is the assignee, L'Air Liquide Societe Anonyme A Directoire et Conseil De Surveillance Pour L'Etude et L'Exploitation Des Procedes Georges Claude, of Paris, France.

2. Related Appeals and Interferences

None.

3. Status of Claims

Claims 1-2, 7-9, 15-16, and 18-25 stand rejected. Claims 3-6, 10-14, 17, and 26-28 have been cancelled. A listing of the claims is attached.

4. Status of Amendments

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amendment would be entered. Accordingly, the claims on appeal are claims 1-2, 7-9, 15-16, and 18-25.

5. Summary of Invention

The invention is an arc/laser hybrid welding process for welding steel workpieces.

Such hybrid welding uses a laser beam simultaneously with an electric arc (specification page 5, second and third full paragraphs; specification page 7, forth full paragraph).

In the invention, a part of the welding zone including the joint currently being welded is shielded with a ternary gas mixture. The ternary gas mixture consists of argon, helium, and one of oxygen and carbon dioxide. The argon and helium have a content of at least 70% by volume. The third gas (O_2 or CO_2) has a non-zero content up to 30% by volume (specification page 7, final paragraph).

The invention's use of this particular ternary gas mixture in laser-arc welding is novel, as to any metals including the recited steel.

6. Issues

A first issue on appeal is whether independent claim 1 was properly rejected under §103(a), over HAMASAKI 4,507,540 in view of STEEN 4,167,662 and YENNI et al.

2,753,427; CHERNE et al. 4,871,898; or GALANTINO et al. 4,749,841 (Group A references).

A second issue on appeal is whether claim 1 was properly rejected under §103(a), over HAMASAKI in view of STEEN and GALANTINO 4,902,866 (Group B references).

A third issue on appeal is whether the dependent claims were properly rejected. Claims 2, 7-9, 15, 22, 23, and 25 were rejected over the Group A references, claims 16, 18, 19, and 21 in further view of BEYER et al. 5,821,493., and claim 20 in further view of COOK 2,790,656. Claims 2, 7-9, 15, 22, and 24 were rejected over the Group B references, claims 16, 18, 19, and 21 in further view of BEYER et al., and claim 20 in further view of COOK.

7. Grouping of Claims

As to each of the first and second issues on appeal, claim 1 stands alone.

As to the third issue on appeal, the dependent claims stand together with independent claim 1.

8. Arguments

Arguments Concerning the First Issue

The first obviousness rejection of claim 1 is over HAMASAKI in view of STEEN and any of YENNI et al., CHERNE et al., and GALANTINO et al.

Claim 1 recites hybrid laser-arc welding of steel workpieces with a ternary gas mixture consisting of argon, helium and either oxygen or carbon dioxide.

The Examiner has offered HAMASAKI disclosing welding steel workpieces by hybrid laser-arc welding and binary gas mixtures.

Thus, although HAMASAKI does disclose hybrid laser-arc welding of steel pieces using various binary gas mixtures, HAMASAKI fails to teach the use of ternary gas mixtures. Specifically, HAMASAKI fails to disclose the recited ternary gas mixture and fails to disclose the specific amounts of the different gases of the gas mixtures as recited. See the first full paragraph on page 3 of the July 16, 2003 Official Action.

Bottom line, the disputed issue is whether any of the applied prior art documents render obvious the use of the recited ternary gas mixture consisting of argon, helium and either oxygen or carbon dioxide, in the concentrations recited, for ***hybrid laser-arc welding*** of steel pieces.

In considering the question of obviousness, one must consider the state of the art at the time of the invention and what would have been obvious to one of skill *at that time*. It is well established that, to establish a *prima facie* case of obviousness, the Examiner must first

consider the relevant teachings of the prior art. Next, the Examiner determines the differences between the pending claim and the prior art teachings. Lastly, the Examiner may propose modifications of the prior art necessary to arrive at the claimed subject matter, but the Examiner must show that there is proper motivation for combining the particular references and for making the proposed modifications to those references. Thus, there must be motivation to modify the references and a teaching or suggestion, in the prior art, of **all** the claim's recitations.

Applying this procedure to the facts of the present case, we see that the Examiner has found prior art (HAMASAKI) disclosing hybrid laser-arc welding of steel pieces using various binary gas mixtures.

The Examiner has not found any prior art disclosing the use of any ternary gas mixture in a hybrid laser-arc welding method.

The Examiner was therefore forced to look outside the welding method being recited; that is, to look outside of hybrid laser-arc welding methods.

As noted above, this obviousness rejection is based on HAMASAKI plus STEEN together with any one of YENNI et al., CHERNE et al., and GALANTINO et al.

In the second full paragraph on page 3 of the July 16, 2003 Official Action, STEEN is offered as disclosing "a hybrid [laser-arc] welding process in which TIG or MIG electrodes can be used" referring to column 4, lines 63-66.

Lines 63-66 actually discloses a welding using an electrode system that may be ***similar*** to that used in MIG or TIG. Thus, STEEN does not appear to teach TIG or MIG welding in a hybrid laser-arc welding process. In any event, STEEN is not offered for the missing ternary gas mixture.

YENNI et al., CHERNE et al., and GALANTINO et al. were each offered as teaching arc welding with a shielding gas mixture of argon, helium, and carbon dioxide.

None of these, however, disclose this gas mixture with hybrid laser-arc welding.

So, at this point we have the prior art disclosing hybrid laser-arc welding with binary gas and arc welding with the ternary gas mixture.

What the Examiner is missing is motivation for using the ternary gas mixture, known only for use in arc welding, in the hybrid laser-arc welding method.

The Examiner's position is essentially that it is obvious to try any technique for arc welding in hybrid welding methods, i.e., "obvious to try". The Examiner has

failed to consider whether one of skill would expect an arc welding teaching to transfer to hybrid welding.

This failure is important as it is known that the prior art laser welding and arc welding techniques do not have the same results and characteristics when applied to hybrid welding; that is, importation of either laser welding or arc welding techniques into hybrid welding is unpredictable.

The amendment of May 1, 2003 made of record The Welding Institute (TWI) public release dated 2002 (copy attached). At the bottom of the first page, TWI reports that synergistic effects of laser-TIG welding were **not** found when low power was used. On the second page of this article, in the paragraph preceding the Main Conclusions section, TWI reports that augmenting a carbon dioxide laser with an arc resulted in less penetration than in laser welding alone. Thus, while hybrid welding was known to offer promise, it was also known that hybrid welding results nonetheless cannot be predicted.

The Examiner, in making the obviousness rejection, fails to consider that one of skill would not assume that gas mixtures known for arc or laser welding could be transferred to hybrid welding applications. The Examiner should have paid attention to the knowledge level that was

present at the time of the invention so as to avoid impermissible hindsight obtained from the present application or subsequent developments in the art.

The prior art understood that laser and arc welding are two very different welding processes such that when arc welding and laser welding are combined, it is often uncertain how they will affect each other. This means that those skilled in the art understand that what may be "true" in arc welding cannot be assumed to be "true" in laser welding or in hybrid welding.

As a consequence, it would be erroneous to consider any gas mixture usable in arc welding is automatically usable in hybrid welding.

Appellants acknowledge that the cited secondary references teach ternary gas mixtures for arc welding. Note, however, that none of these references concern hybrid welding or suggest hybrid welding and so none of these references teach a benefit of using a ternary gas mixture to improve hybrid welding. Indeed, in each instance where hybrid welding is disclosed in the prior art, there is no disclosure of using a ternary gas, and in any instance where a ternary gas mixture is disclosed, there is no disclosure using such gas mixture in hybrid welding. Appellants believe that this clearly points to the prior art not

appreciating any benefit from using ternary gases in conjunction with hybrid welding.

It seems that the Examiner effectively used the present disclosure to render the claimed invention obvious. Such an approach is not permitted.

Relevant to this point, the Federal Circuit emphasized in July, 1998 that "[m]ost, if not all, inventions are combinations and mostly of old elements." *In re Rouffett*, 47 USPQ 2d 1453, 1457 citing to *Richdel, Inc. v. Sunspool Corp.*, 219 USPQ 8, 12 (Fed. Cir. 1983). The Federal Circuit continued by noting that "rejecting patents solely by finding prior art corollaries for the claimed elements would permit an examiner to use the claimed invention itself as a blue print for piecing together elements in the prior art to defeat the patentability of the claimed invention."

Thus, the Federal Circuit requires that in order to prevent the use of such hindsight, the Official Action must "show reasons that the skilled artisan, confronted with the same problems as the inventor and with no knowledge of the claimed invention, would select the elements from the cited prior art references for combination in the manner claimed." (*In re Rouffett* at 1458).

Appellants believe that it is clear that although the prior art was aware of the use of ternary gas mixtures for arc welding, the prior art fails in any instance to suggest such use in hybrid welding. When avoiding the use of hindsight, it is clear the claim 1 is non-obvious. Therefore the obviousness rejection can not be maintained.

Arguments Concerning the Second Issue

A second obviousness rejection is over HAMASAKI in view of STEEN and GALANTINO.

As with the first obviousness rejection, the combination of HAMASAKI and STEEN is acknowledged not to teach the recited ternary gas mixture.

GALANTINO teaches a ternary gas mixture of argon, helium, and oxygen. GALANTINO teaches this ternary gas mixture for arc welding.

Thus, this second obviousness rejection is the same as the first obviousness rejection except for showing the alternative third gas (oxygen instead of carbon dioxide). In view of this, appellants believe this rejection fails for the same reasons argued as to the first obviousness rejection.

Accordingly, as to this second obviousness rejection, the Examiner also fails to establish a *prima facie*

case of obviousness. Therefore, the rejection can not be maintained.

Arguments Concerning the Third Issue

The dependent claims are believed allowable at least for depending from allowable claim 1.

9. Conclusion

In view of foregoing, it follows that the obviousness rejections are all improper and should be reversed.

Reversal of these rejections is accordingly respectfully solicited.

Respectfully submitted,

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December 19, 2003

10. Appendix

The claims on appeal:

1. (previously presented) A process for welding one or more metal workpieces to be joined together by producing at least one welded joint between edges to be welded of said metal workpiece or workpieces, said workpiece or workpieces being made of steel, by using at least one laser beam and at least one electric arc, in which process, during welding of the joint, shielding at least one part of a welding zone comprising at least one part of said welded joint during welding with at least one shielding atmosphere formed by a ternary gas mixture consisting of:

argon;

helium, the argon and the helium with a content greater than or equal to 70% by volume; and

a third gas consisting of O_2 or CO_2 with a content of non zero to 30% by volume.

2. (previously presented) The welding process as claimed in claim 1, wherein the content of O_2 or CO_2 is non zero and less than or equal to 20% by volume.

3-6. (cancelled)

7. (previously presented) The welding process as claimed in claim 1, wherein the shielding atmosphere is

formed by a gas mixture consisting of at least 70% by volume of helium and argon and of 0.1 to 30% by volume of O_2 or CO_2.

8. (previously presented) The welding process as claimed in claim 1, wherein the workpiece or workpieces to be welded are made of coated or uncoated steels.

9. (previously presented) The welding process as claimed in claim 1, wherein the workpiece or workpieces to be welded are made of stainless steel or carbon steel.

10-14. (cancelled)

15. (previously presented) The welding process as claimed in claim 1, wherein the laser beam is emitted by an Nd:YAG or CO_2 laser and/or wherein the electric arc is a plasma arc.

16. (previously presented) The welding process as claimed in claim 1, wherein the electric arc is delivered by a plasma-arc torch.

17. (cancelled)

18. (previously presented) The welding process as claimed in claim 1, wherein said metal workpiece comprises at least one tailored blank intended to constitute at least one part of a vehicle body element.

19. (previously presented) The welding process as claimed in claim 1, wherein said metal workpieces have different thicknesses.

20. (previously presented) The welding process as claimed in claim 1, wherein said metal workpieces have the same or different thicknesses and have different metallurgical compositions or metallurgical grades.

21. (previously presented) The welding process as claimed in claim 1, wherein the edges comprise two longitudinal edges of a pre-tube.

22. (previously presented) The welding process as claimed in claim 1, wherein the electric arc is generated by a consumable or a non-consumable electrode.

23. (previously presented) The welding process as claimed in claim 1, wherein the third gas consists of CO_2 with a content of non zero and less than 15% by volume.

24. (previously presented) The welding process as claimed in claim 1, wherein the third gas consists of O_2 with a content of non zero and less than 5% by volume.

25. (previously presented) The welding process as claimed in claim 1, wherein the third gas consists of CO_2 with a content of non zero and less than 2% by volume.

26-28. (cancelled)

Background

The tungsten inert gas (TIG) arc welding process was the first to be combined with a laser beam to produce an arc-augmented laser, or hybrid laser-arc weld in the mid 1970s (1). Since then, laser welding has successfully been augmented with other arc processes such as metal inert/active gas (MIG/MAG) welding and plasma welding. The advantages of using hybrid laser-arc welding for increased productivity include faster welding speeds, improved penetration, enhanced gap bridging capability and reduced porosity compared with conventional laser welding. Hybrid welding has been studied for application in industries such as automotive (5), oil and gas (7, 8), shipbuilding (9) and nuclear (10).

This report reviews the published literature on the capabilities of hybrid laser-arc welding. Also, a programme of experimental work was undertaken to establish suitable procedures for hybrid CO_2 laser-MAG arc welding carbon steel, compared to welding with the individual processes.

Objectives

- To review published literature on hybrid laser-arc welding to establish procedures for initial trials for hybrid CO_2 laser-MAG welding carbon steel.

- To determine process guidelines for using hybrid CO_2 laser-MAG welding technology for welding steel.

Summary of Literature Review

Experimental research into laser-arc hybrid welding has demonstrated that it combines many of the best features of the individual processes. MIG/MAG welding provides a relatively wide bead and good tolerance to variations in fit-up and the possibility of metallurgical control. Laser welding provides deep penetration welds at fast welding speeds. The synergistic action of combining the individual processes is more than simply additive: considerable reductions in costs and improvements in productivity are achievable relative to the separate processes.

The use of filler wire and a more diffuse heat source with the arc process means that hybrid laser-arc welding can tolerate misalignments and large root gaps in thick section welding better than laser welding alone. Therefore the accuracy and tolerances required for workpiece preparation are relaxed.

For the very low additional costs of the arc compared with the laser, hybrid welding reportedly offers faster welding speeds and lower cycle times thus, the production cost per unit can be reduced compared to laser welding. A reduction in investment costs for laser technology will further facilitate the acceptance of the process for future industrial applications. In most cases the enhancement of weld penetration of hybrid welding compared with laser alone welding has been reported. However, this is not always the case. Scott (38) concluded that there were no synergistic effects of the laser increasing the penetration of TIG welds in several aluminium alloys.

However, these results were explained by the low power laser used, which did not produce a keyhole.

Experimental Approach

Following an extensive literature review, a programme of work was undertaken to establish the feasibility of using hybrid CO_2 laser-MAG welding of carbon steel in order to obtain greater weld penetration at faster speeds than for laser welding. Processing parameters investigated in this assessment of hybrid laser-arc welding include gas composition, welding speed, welding direction (laser trailing or leading the arc) and MAG metal transfer mode.

Results and Discussion

The literature review showed that it is possible to improve productivity using the hybrid laser-arc welding process, compared with either laser or MAG arc welding. Costs are considerably reduced using a hybrid laser-arc process compared with a laser only process of equivalent power.

Bead-on-plate welding trials used a MIG/MAG welding torch inclined at 60° to the workpiece, and pulsed and dip metal transfer conditions of equivalent power to the 4kW CO_2 laser. A 3kW MAG arc using a pulsed metal transfer condition, 4kW CO_2 laser, He-Ar-CO_2 shielding gas and the arc trailing the laser was found to give 25% greater penetration than the laser welds. For a given penetration, these conditions also gave a 50% increase in welding speed compared with a laser weld. The thermal efficiency factor of the hybrid process is increased to 0.9, compared with 0.78 or 0.8 for CO_2 laser or MAG welding respectively, for welding speeds up to 3.0 m/min.

Trials were also undertaken to investigate welding with a 4.2kW CO_2 laser augmented with a 12.5kW MAG arc. Spray metal transfer conditions and a shallow torch inclination angle of 40° was used. and the shielding gas was He-Ar-CO_2. The penetration of these hybrid welds was less than the penetration in laser welds. This was due to the high arc currents used in the spray metal transfer condition causing an excess of weld metal in the keyhole. effectively blocking the penetration of the laser.

Main Conclusions

- He-Ar-CO_2 shielding gas was found to give the best combination of process stability and penetration for hybrid 4kW CO_2 laser-3kW pulsed MAG welding.
- The MIG/MAG welding torch trailing the CO_2 laser for a hybrid 4kW CO_2 laser-3kW pulsed MAG welding process was found to increase penetration of the hybrid weld.
- For a constant depth of penetration (in this case 4.2mm penetration) the hybrid CO_2 laser-MAG welding process was capable of increasing welding speed by around 50% compared to laser alone welding.

- Hybrid CO_2 laser-MAG welding provided an increase in weld penetration of 20-35% compared with laser alone welding at constant welding speed of 3.0 m/min.

- The average process efficiency factor was found to be 0.9 for hybrid 3.8kW CO_2 laser-2.6kW MAG welds, compared with approximately 0.8 for the individual laser and MAG processes. The total weld area of hybrid 3.8kW CO_2 laser-2.6kW MAG welds was greater than the sum of the weld areas for the individual processes below 3.0 m/min.

Recommendations

It is recommended that to improve the penetration and welding speed of bead-on-plate welding carbon steel, the following welding conditions using a hybrid CO_2 laser-MAG welding process are:

- Pulsed MAG metal transfer conditions;
- 55%He-43%Ar-2%CO_2 shielding gas;
- 1.5 m/min welding speed;
- MAG arc trailing the laser;
- 0mm separation between the MAG arc and the CO_2 laser in the molten pool.